

## Pressurized pipe systems

Measurement of flow of water in pressurized pipe systems is done with a mechanical or electronic meter. There are many styles and types of meters, and care must be taken to ensure that the meter a user installs fits the system. Commonly used meters are propeller meters, magnetic meters, paddle wheel meters, vortex shedding meters, positive displacement meters, and ultrasonic meters, to name a few.

### Selecting a meter for pressurized pipe systems

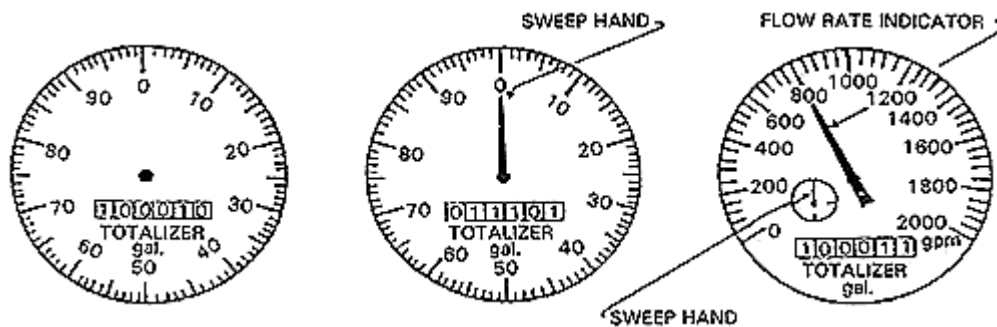
Selecting a meter for pressurized systems can be confusing because of the different types and styles available on the market. A meter must be matched to the system, and the water user has to tell the meter dealer the following basic information to make sure a meter matches the system.

- Know the range of flow under which the system operates. In other words, what is the smallest volume of water and the largest volume that will be pumped. For instance, a system may need to pump as little as 20 gallons per minute for the smallest set of water to as much as 120 gallons per minute for the largest set. The lower volume of 20 gallons per minute will eliminate some types of meters because those meters cannot accurately measure amounts that low. In some cases, a meter that will measure the lowest flow for a system may not be able to measure the highest flows used in that system. The user needs to know that, too.
- A meter must be able to measure the instantaneous quantity ( $Q_i$ ) and record the total quantity of water used over time ( $Q_a$ ).  $Q_i$  is the rate at which water is pumped, such as 20 gallons per minute, 550 gallons per minute, and so forth. The total quantity pumped over time may be recorded as gallons, tens of gallons, hundreds of gallons, or thousands of gallons. Totalizing use in gallons is standard for meters. If recording  $Q_a$  in acre-feet is desired, the user must order that requirement. **For most uses in agriculture, recording  $Q_a$  in acre-feet is best. If totalizing  $Q_a$  in acre-feet is not available, then order a meter that records in thousands of gallons, or 10 thousand gallons, if possible.** Once installed, be sure the dealer explains how to read the meter.
- The size of the pipe is very important. Users may have to use a reducer in the system if required for the meter. Try to obtain a meter that will fit in the existing system without having to use a reducer in the pipe.
- Be sure that there is enough straight pipe before and after the meter. Read the instructions for installation. Not all meters have the same requirements. In most cases, the required lengths are a function of the diameter of the pipe. For instance, most propeller meters require 5 times the diameter of pipe of straight pipe before the meter, and 2 times the diameter after the meter. So a 6-inch pipe would need 30 inches of straight pipe before the meter and 12 inches of straight pipe after the meter.
- If the required lengths of straight pipe are not available, particularly before the meter, then straightening vanes would be required.
- Be sure the accuracy of the meter is within prescribed limits, which are plus or minus 5% of the amount actually being pumped. Most, if not all, meters are calibrated at the factory and operate well within that range.
- All meters should be inspected periodically as part of a scheduled maintenance program, especially meters that have moving parts. Generally, meters are checked for two reasons: to confirm that it's still operating or to assess its accuracy.

## What does the readout on a meter head look like?



**Figure 1.** An example of the readings an electronic readout should provide

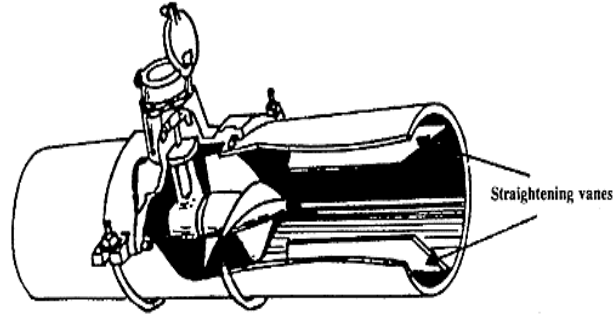


**Figure 2.** What a mechanical meter head might look like and what readings are provided. For agricultural applications, totalizing in acre-feet is best.

## Straightening Vanes

Water flows through a pipe relatively uniformly with a minimum of turbulence as long as the pipe is straight. Meters measure water with a high degree of accuracy in straight pipe, but whenever the pipe takes a bend, such as at an elbow, the flow becomes turbulent for a short while. The water has to travel "straight" for a while in order to return to non-turbulent flow. It is important that a meter not be placed in the pipe where turbulence exists as turbulence causes the meter to read the amount of water incorrectly. The error may or may not be in favor of the water right holder. Most likely it will not be in favor of the water right holder. Instead, meters should be placed where turbulence is reduced. Some meters require a greater length of straight pipe than others. Look at the directions for installing the meter and make sure that the minimum requirement of straight pipe, both before and after the meter, is available in order to ensure accuracy. The length of straight pipe needed after the meter is considerably less than before the meter.

If the required amount of straight pipe is not available for whatever reason, straightening vanes are an option. Straightening vanes are used in order to reduce turbulence and provide a more consistent flow of water in a pipe ahead of the meter. Consistent flow improves meter accuracy for the end user. Most straightening vanes are made in accordance with the requirements and standards of the API. Straightening vanes may be necessary for any meter, depending on the length of straight pipe ahead of a meter. If there is not enough length of straight pipe ahead of the meter, then straightening vanes would be required. Look at the instructions for the meter, and ask the meter installer about the need for straightening vanes.



**Figure 3.** Meter with straightening vanes ahead of the meter.

## Installing a Meter on the Pipe

There are a number of ways to install a meter on a pipe. The usual methods are:

**Threaded pipe fitting:** This method involves cutting a hole in the pipe, welding on a threaded pipe fitting, and screwing the meter into the pipe fitting. This type of installation is usually for insertion-type meters where the meter is inserted into the pipe (insertion means that a part of the metering system has an element of the meter inserted into the pipe flow), such as with paddle wheel meters, vortex meters, and some types of magnetic meters.

**Saddle meter mount:** involves cutting a hole in the pipe and installing a saddle mounted meter. This type of installation can be used for all types of meters that require having some type of projection inserted into the pipe, such as propeller meters, paddle wheel meters, vortex meters, and some types of magnetic meters.



**Figure 4.** Typical saddle mounts for installing a meter in a pipe



**Figure 5.** Example of a propeller meter with a saddle mount

Flanged meter: involves cutting a section of the existing pipe out of the system, installing flanges on both ends, and placing the flanged meter in place of the cut out section. Often used when straightening vanes are required.



**Figure 6.** Example of a typical flanged meter with straightening vanes.

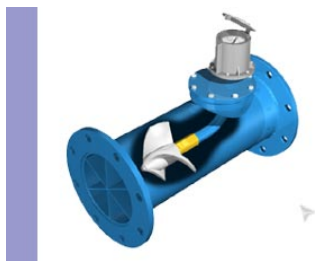
## TYPES OF PRESSURIZED PIPE FLOW METERS

### Mechanical Flow Meters

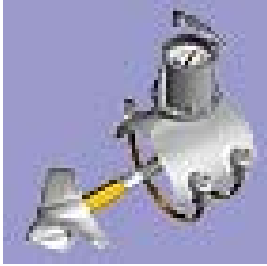
Mechanical meters are probably the most used type of meter for pressurized systems. There are several types of mechanical flow meters available over a range of costs. The following is not to be considered an all-inclusive list of mechanical flow meters. There are others; this discussion only provides a brief overview of meters commonly used in many applications.

#### Propeller meters

Propeller meters are the most common type of meter in use for measuring water at the source in pressurized water delivery systems. Propeller meters are relatively accurate and meet the needs of most users. The readout on the meter provides  $Q_a$  and  $Q_i$ , and does not require power to operate unless equipped with an electronic readout for  $Q_i$  and  $Q_a$ . Propeller meters are not recommended when water is dirty and contains abrasive material such as sand. A rule of thumb is that if the impellers on a pump have to be replaced often, then propeller meters are probably not the best choice due to abrasive wear on the meter propeller. Propeller meters can be equipped with electronics for SCADA (see SCADA webpage).



**Figure 7.** Flanged propeller meter with straightening vanes



**Figure 8.** Saddle mount propeller meter

## Positive displacement meters

Positive displacement meters use chambers with dual-stage pistons. The incoming water fills a known volume of the measuring chamber on one or the other side of a movable disc that separates the chamber into two sections. As water enters it moves the disc, forcing a known volume of water out of the meter from the opposite side of the disc. The process repeats as the sections refill and empty in turn. The action of the disc is coupled to the register to indicate the volume of water that passes through the meter. This type of meter is often used on small systems that pump less than 36 gallons per minute. Totalizing in acre-feet may not be available, and usually record in hundreds of gallons. All direct read meters are usually able to be modified for using SCADA (see SCADA webpage). Sizes include 5/8" to 2" offered with a variety of material configurations and registers, and types of materials.



**Figure 9.** Example of a positive displacement meter.

## Paddle wheel meters

Paddle wheel meters use a small paddle wheel inserted into the flow of water. It works much the same as a propeller meter except that the paddle wheel does not need to be inserted far into the flow of water as compared to a propeller meter. This type of meter uses electronics to read and display flow of water in a pipe. These types of meters work over a wide range of flow and can be used with SCADA (see SCADA webpage). However, paddle wheel meters are not recommended if the water contains abrasive materials.



**Figure 10.** Example of a paddle wheel meter

## Electronic flow meters

Electronic flow meters operate by using electronic components and no moving parts. This type of meter is more technical in application and use than what is typical of mechanical meters; however, mechanical meters can be equipped with electronics and used for SCADA applications (see SCADA webpage). **Electronic components of any system should be provided protection from lightning strikes or any kind of possible electrical disturbance that can “fry” the electronic components or cause data to be lost.**

Typically, electronic flow meters are set up either in the field or at the factory to the specifications of the user, such as readout of  $Q_i$  in gallons or cubic feet per second.  $Q_a$  can be set up to record in gallons to thousands of gallons or in acre-feet. **For agricultural applications, it is always recommended that the meter be set up to record in acre-feet.**

Electronic meters can be very basic in application and used only to measure  $Q_i$  and totalize  $Q_a$ , much the same as mechanical meters. The value in electronic meters for many applications is that there are no moving parts. These types of meters either do not require any projections of the meter into the pipe flow, or, if they do, the projection is small in comparison to the flow of water.

## Vortex flow meters (Fig. 11)

Vortex flow meters measure flow by detecting how often vortices are alternately shed from a bluff body (a small obstruction in the stream of flow), much in the same way a flag flutters in the wind. Each flap of a flag is a vortex, and the faster vortices are made, the faster is the breeze. Vortex meters measure the rate of “flapping” that occurs when water flowing in a pipe flaps around the bluff body inserted into the stream of water (see illustration).

Rate of flow and total quantity of water pumped is displayed on an electronic display, so a power source is required, usually a battery or a battery with a solar panel. Users must specify recording  $Q_a$  in gallons or acre-feet. The manufacturer will set the recorder at the factory to the desired setting.

Vortex meters have a small projection into the pipe, therefore a hole must be tapped into the pipe for the vortex body. The meter can be mounted either on a threaded pipe fitting welded to the pipe or on a saddle mounting.



**Figure 11.** Example of vortex meters

### Ultrasonic flow meters

A number of companies make ultrasonic meters (Fig 12). Ultrasonic meters use sound to measure water. These meters work on all pipe materials except concrete. Advantages are:

- Clamps on to the outside of a pipe\*\*. Can be used in applications where water is dirty and contains sediments that tend to damage or impede mechanical flow meters.
- Accurate and versatile.
- Totalizing can be in gallons or acre-feet. Some makes can be set in the field to the users specifications. **Totalizing Qa in acre-feet is best for agricultural applications.**
- Power requirements can be met with 110/230 volt, batteries and/or solar panels.
- Can measure a very broad range of flow from 0 to 20,000 gallons per minute and more.
- Costs are higher than mechanical or insertion-type meters.

\*\*One key point to remember on ultrasonic meters is that the transponders need to be installed with a special sealant between the transponder and the pipe to ensure that there are no air pockets. Users need to ensure that the seal is maintained.



**Figure 12.** Example of ultrasonic meters installed on a pipe.

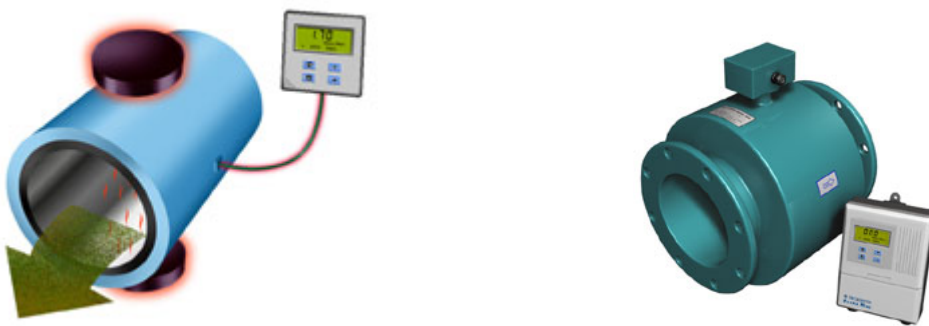
### Magnetic flow meters

Magnetic (mag) meters work by generating a magnetic field. As water passes by or through the meter in the pipe, a voltage directly proportional to the rate of flow is generated. The voltage is measured by electrodes inserted through the flow meter lining in the case of a meter that is part

of the pipe, or by electrodes inserted into the pipe in the case of insertion-type mag meters. Readings are converted to rate of flow and measurement of total flow.

There are two types of mag meters – full pipe size (Fig 13) and insertion style (Fig 14). Mag meters operate under a wide range of flow, beginning with 0 flow, and can be sized for any size pipe. They can be used in conditions ranging from clean water to very dirty water, with few, if any, problems with corrosion and wear. All mag meters can be used with SCADA.

Full pipe size mag meters are built to the size of pipe of the system in which they will be used. These meters are made to order by the manufacturer. While expensive, they have technical advantages over most meters. Full pipe size mag meters do, however, require a 110 volt – 120 volt power source, which is usually not a problem because the meter is usually located close to the pump, which already has a power source. Readings are electronic.



**Figure 13.** Examples of full pipe size mag meters with readout attachments

Insertion-style mag meters work by inserting an electrode head into the pipe flow. The operation is the same as for full-pipe size mag meters. There are a number of manufacturers of this type of mag meter, and there may be limitations as to how large a pipe on which a particular brand can be used in larger pipe sizes. If a user is considering an insertion mag meter, the manufacturer must be consulted to determine if the meter would work in the pipe size of the system. Insertion mag meters are lower in cost than the full pipe size mag meters, but have technical limitations that full-size pipe mag meters do not have.



**Figure 14.** Examples of two types of magnetic insertion meters

## Links on meters and metering

The following links provide guidance on propeller flow meters

<http://ianrpubs.unl.edu/irrigation/g392.htm#instal>

<http://www.ext.colostate.edu/pubs/crops/04710.html>

This link to the Bureau of Reclamation *Water Measurement Manual* provides excellent technical advice on both open channel and pressurized pipe systems.

[http://www.usbr.gov/pmts/hydraulics\\_lab/pubs/wmm/index.htm](http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/index.htm)